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IX.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

CRYSTALLOGRAPHIC NOTES.

By Oliver W. Huntington.

Communicated by the Corresponding Secretary, June 10, 1885.

Crystals of Azurite from Arizona.

The mineral cabinet of Harvard College has recently received, through the kindness of Mr. Godfrey Hyams, some very interesting groups of azurite crystals. The specimens came from the mines of the Detroit Copper Company, situated near Clifton in the extreme eastern portion of Arizona, and I am indebted to Mr. Hyams for the following description of their occurrence.

"The formation in which the deposits are situated is peculiar to these mines, so far as I know. The zones or belts of copper occur in a sort of felsite on a contact between lime and iron, the lime being calcite and the iron an oxidized compound of varying composition. Specimens analyzed have given results which show that hematite, limonite, turgite, and clay iron-stone all occur.

"The ore appears in different forms: —

"1. Malachite, as fibrous, botryoidal, stalactitic, encrusting, and massive.

"2. Azurite, fibrous, botryoidal, encrusting, massive, and lastly crystallized.

"The crystals occur in various ways; singly on or in different manganiferous clays, in clusters like stilbite, in plates like nail-head spar, and in columns around a central axis like rock-candy.

"The two carbonates are in every phase of transition. We have malachite changing into azurite, that is, the malachite outside and azurite inside, then the reverse, malachite pseudomorph after azurite, and *vice versa*. Then again specimens of native copper occur in parts covered with crystals of cuprite, and these crystals in turn incrusted with malachite. With these are also large masses of cuprite, chrysocolla, and some native copper, but as yet, even at a depth of over two hundred feet, no sulphides have been discovered, — a condition which is very unusual.

"There is another form in which the azurite is found, which resembles the Chessy deposits, that is, in a quartzose rock scattered in nuggets varying from the size of a pea to that of a walnut. All the ores carry, besides iron and silica, a small percentage of manganese and alumina, together with an amount of zinc varying from two to eight per cent."

The specimens received at the cabinet of Harvard College consisted of large masses of transparent crystals closely packed together, accompanied by beautiful stalactites consisting mainly of azurite, but coated over with malachite, the malachite usually covering the azurite.

Many of the crystals resemble closely those from Chessy, being grouped together so as to give a general rhombohedral aspect, having rounded faces and looking not unlike saddle-back crystals. These saddle-back crystals were all more or less rough, dull, and opaque; but with them were associated numerous brilliant transparent glassy crystals elongated on the ortho-diagonal, having the general aspect shown in the accompanying sketch (Fig. 1).

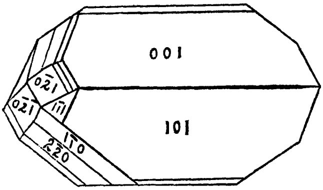

Fig. 1.

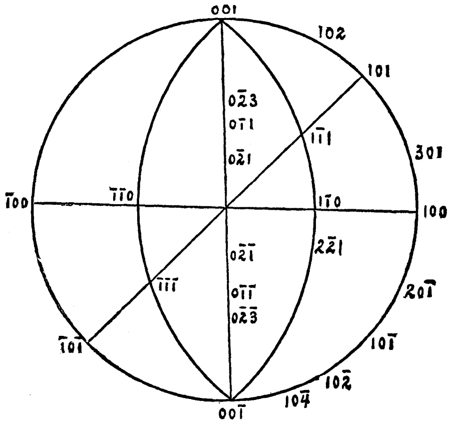

Fig. 2.

These crystals presented no new planes, and corresponded in their crystallographic elements so closely with those given by Des Cloizeaux that it seemed best to refer the planes to the same axial dimensions. The measurements were made with a reflecting goniometer, having a micrometer screw graduated to ten seconds; but since the planes were usually rounded or badly striated, the reading could only be accurately made in comparatively few cases, and in the table below the best angles have been indicated by heavy-faced type.

$$C = 87^\circ\ 39'. \quad c : b : \grave{a} = 1.0378 : 1.1807 : 1.$$

ORTHO-DIAGONAL ZONE.

	DES CLOIZEAUX.	
$001 \wedge 102$	27° 55′	26° 35′
$001 \wedge 101$	47° 6′	**47° 3′**
$001 \wedge 301$	74° 20′	**74° 20′**
$001 \wedge 100$	92° 21′	92° 33′
$100 \wedge 20\bar{1}$	25° 16′	26° 8′
$100 \wedge 10\bar{1}$	42° 48′	43° 15′
$100 \wedge 10\bar{2}$	59° 44′	64° 28′
$100 \wedge 10\bar{4}$	73° 16′	70° 51′
$00\bar{1} \wedge 10\bar{4}$	14° 23′	17° 19′

CLINO-DIAGONAL ZONE.

	DES CLOIZEAUX.	
$001 \wedge 0\bar{2}3$	30° 21′	31° 31′
$001 \wedge 0\bar{1}1$	41° 17′	40° 22′
$001 \wedge 0\bar{2}1$	60° 21′	60° 37′
$0\bar{2}1 \wedge 0\bar{2}\bar{1}$	59° 18′	**59° 7′**

PYRAMIDAL ZONE.

	DES CLOIZEAUX.	
$001 \wedge 1\bar{1}1$	54° 40′	54° 44′
$001 \wedge 1\bar{1}0$	91° 48′	**91° 48′**
$1\bar{1}0 \wedge 2\bar{2}1$	19° 58′	19° 46′
$2\bar{2}1 \wedge 00\bar{1}$	68° 13′	68° 28′

VERTICAL ZONE.

	DES CLOIZEAUX.	
$100 \wedge 1\bar{1}0$	40° 14′	40° 16′
$1\bar{1}0 \wedge \bar{1}\bar{1}0$	99° 32′	**99° 30′**
$\bar{1}\bar{1}0 \wedge \bar{1}00$	40° 14′	**40° 15′**

OBLIQUE ZONE.

	DES CLOIZEAUX.	
$101 \wedge 1\bar{1}1$	31° 53′ 30″	**31° 55′**
$1\bar{1}1 \wedge \bar{1}\bar{1}\bar{1}$	116° 13′	**116° 18′**
$\bar{1}\bar{1}\bar{1} \wedge \bar{1}0\bar{1}$	31° 53′ 30″	**31° 50′**

The planes of the main prism zone parallel to the ortho-diagonal, and those of the clino-diagonal zone, were very badly striated, and somewhat rounded, so that most of the measurements were made from mere flashes, only three of the angles being sharply defined. The remaining three zones were more sharply defined, and it will be noticed that in these zones the measurements more nearly coincide with those of Des Cloizeaux, and in every case they coincide within the probable limit of error due to the irregularity of the planes.

Quartz Twins.

In the September number of the American Journal of Science, Prof. W. G. Brown of the University of Virginia describes a group of twin crystals of amethystine quartz from Albemarle County, Virginia, which appear to resemble in structure twins originally described by G. Rose,* and which he interpreted as twinned parallel to the fundamental rhombohedron, although united by a plane perpendicular to the same rhombohedral face. It appears, however, as originally shown by Nauman,† that the structure of these groups might be interpreted as twins of the ordinary type, parallel to a rhombohedral face, $-\frac{5}{8}$ R, and the group examined by Professor Brown would seem to confirm this view, in so far as the corresponding rhombohedral faces of the twins are not absolutely in the same plane; although the irregularities he describes may obscure the small angular difference of twenty-six minutes, which could alone furnish decisive evidence as between the two theories under discussion.

Professor Brown also refers to the view of Ecle,‡ strengthened by the observations of Rath and Frenzel,§ and that of E. S. Dana,|| that

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* Poggendorf's Annalen, lxxxiii. 461, 1851.

† Elemente der Mineralogie, 6th ed., p. 190, 1864.

‡ Zeitschr. d. deutsch. geol. Gesellschaft, xviii. 428, 1866.

§ Poggendorf's Annalen, xvii. 155, 1875.

|| American Jour. of Science, III., xii. 448, 1876, and Zeitschr. für Krystall., i. 39, 1877.

similar twins might result from the growth of quartz crystals on a nucleus of calcite.

Through the kindness of Professor Brown the writer had an opportunity of measuring and studying the specimen from Albemarle County, Virginia, and he was thus led to measure with accuracy all the similar groups of quartz crystals in the mineral cabinet of Harvard College, and the following observations may be of value as additional evidence in regard to the phenomena in question. Out of a very large number of apparent twins, there were only three in which faces on any two individuals fell absolutely into the same zone, and in which an assumed plane of twinning could be referred, within the limits of error, to probable axial ratios.

The measurements on these crystals were as follows: —

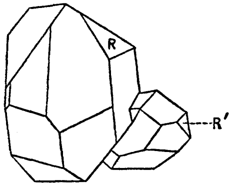

Fig 3.

In the accompanying sketch (Fig. 3), we have R and R' in the same zone, and $R \wedge R' = 21° 32'$. Axial divergence $= 125° 6'$.

We find from this, that the assumed twinning plane would be a rhombohedral face with the axial ratio 0.4488, and this compared with the known fundamental ratio 1.0999 corresponds almost absolutely to a negative rhombohedron, $-\frac{9}{22}$.

With the group of crystals shown in Fig. 4 the same zone was measured, giving $R \wedge R' = 50° 26'$. Axial divergence $= 153° 59'$. Axial ratio for assumed plane of twinning $= 0.19994$. This compared with the fundamental ratio corresponds exactly to the negative rhombohedron $-\frac{2}{11}$.

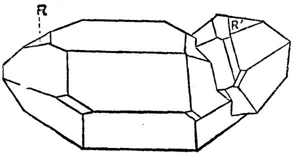

Fig. 4.

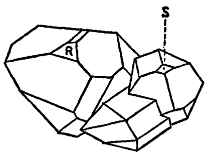

Fig. 5.

The group of crystals, Fig. 5, differed from the previous ones in having a plane of the direct hexagonal pyramid of one individual, and a plane of the indirect pyramid of the other, in a zone with the axes.

$R \wedge s = 14° 44'$. Axial divergence $= 117° 59'$. Axial ratio of assumed plane of twinning $= 0.3850$. And this corresponds absolutely to the negative rhombohedron $-\frac{7}{20}$.

The examples here given show a wonderfully close coincidence with possible though somewhat complex ratios, but it must be remembered that these are only three out of a very large number of apparent twins, in which no such relation could be established. The following will serve as an illustration.

A group of crystals was found differing from the previous ones in no essential respects, in which R and R' were in a zone with the principal axes, making an angle with each other of 4° 8′. This would correspond to a twinning plane with an axial ratio of 0.63267, which bears no assignable relation to the fundamental rhombohedron. In other cases the approximation to possible ratios was much closer than this; but in most instances the planes on the two crystals were not even in the same zone, and every variation was noticed, from examples in which the reflected images would fall within the field of the telescope of the goniometer to those in which there was a much wider divergence, the crystals being displaced to a greater or less extent on the plane of twinning.

It will be seen by the above examples that in some cases the direct pyramid is in the same zone with the direct pyramid on the twin crystal, and in other cases it is in the same zone with the indirect; but intermediate positions were noticed, which would result from a greater or less rotation of one of the crystals on its own axis.